

CLAIMS

1°) Genetically modified plants, characterized in that they include one or more than one copy of at least a sequence encoding a P_{1B}-type ATPase of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass and that they overexpress said P_{1B}-type ATPase.

5 2°) Genetically modified plants according to claim 1, characterized in that they are able to accumulate heavy metals and translocate them to the shoots.

3°) Genetically modified plants according to claim 1 or claim 2, characterized in that said P_{1B}-type ATPase is selected from the group consisting of heavy metal eukaryotic ATPases HMA1, HMA2, HMA3 and HMA4.

10 4°) Genetically modified plants according to claim 3, characterized in that said P_{1B}-type ATPase is selected from the group consisting of endogenous ATPases HMA1, HMA2, HMA3 and HMA4.

5°) Genetically modified plants according to claim 3, characterized in that said P_{1B}-type ATPase is selected from the group consisting of heavy metal
15 ATPases HMA1, HMA2, HMA3 and HMA4 of *Arabidopsis thaliana*.

6°) Genetically modified plants according to any of claims 1 to claim 5, characterized in that said genetically modified plants include one or more than one copy of at least two different sequences encoding two different P_{1B}-type ATPases of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass.

20 7°) Genetically modified plants according to claim 6, characterized in that said genetically modified plants include one or more than one copy of at least HMA3 and HMA4.

8°) Genetically modified plants according to any of claims 1 to claim 7, characterized in that they include one or more than one copy of a sequence
25 encoding at least a P_{1B}-type ATPase of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass and at least another sequence selected among sequences encoding (1) an enzyme involved in metal chelation or (2) another metal transporter such as YCF1 or other ABC transporters.

9°) Genetically modified plants according to claim 8, characterized
30 in that said enzyme involved in metal chelation is selected from the group consisting of phytochelatin synthase, glutathion synthetase and gamma-glutamylcystein synthase.

10°) Recombinant vector able to transform plants, characterized in that said vector includes one or more than one copy of at least a sequence encoding a P_{1B}-type ATPase of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass, wherein said ATPase is able to translocate heavy metals to the shoots of a plant when expressed in said plant.

5 11°) Recombinant vector according to claim 10, wherein said ATPase is selected from the group consisting of eukaryotic ATPases HMA1, HMA2, HMA3 and HMA4.

10 12°) Recombinant vector according to claim 10 or claim 11, characterized in that said coding sequences are operably linked to and under the regulatory control of a plant-expressible transcription and translation regulatory sequence, such as a plant specific promoter.

 13°) Recombinant vector according to any of claims 10 to 12, characterized in that it comprises a first sequence encoding HMA3, and a second sequence encoding HMA4.

15 14°) A set of recombinant vectors according to any of claims 10 to 12, characterized in that it comprises at least a first vector encoding HMA3 and a second vector encoding HMA4.

 15°) Genetically modified plants, characterized in that they are transformed with a recombinant vector according to any of claims 10 to 13, or with a set of vectors according to claim 14.

 16°) Genetically modified plants, as defined in any one of claims 1 to 9 and 15, characterized in that said plants are selected in the group consisting of *Brassica juncea*, *Poplar*, *Nicotiana tabacum*.

25 17°) Plant cells characterized in that they are transformed with a recombinant vector according to any of claims 10 to 13, or with a set of vectors according to claim 14.

 18°) Use of genetically modified plants according to any one of claims 1 to 9, 15 or 16, for phytoextraction of Zn, Co, Cd or Pb, from a contaminated environment.

30 19°) Use of genetically modified plants according to claim 7, for phytoextraction of Co, Cd or Pb, from a contaminated environment.

20°) Method of producing genetically modified plants according to claims 1 to 9, 15 or 16 which overexpress at least a P_{1B}-type ATPase of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass, said method comprising:

- preparing at least one recombinant vector(s) according to any of
5 claims 10 to 13, comprising one or more than one copy of at least a sequence encoding a P_{1B}-type ATPase of the Zn²⁺/Co²⁺/Cd²⁺/Pb²⁺ subclass, operably linked to and under the regulatory control of a plante-expressible transcription and translation regulatory sequence and
- introducing said at least one recombinant vector(s) into a plant cell
10 or plant tissue to produce a genetically modified plant cell or a genetically modified plant tissue.

21°) Method of phytoremediation of heavy metals from soil, characterized in that it includes:

- a step of planting genetically modified plants according to any one
15 of claims 1 to 9, 15 or 16, in an area containing soil contaminated with at least one heavy metal and
- collecting and removing plant tissues from said genetically modified plants at appropriate time intervals.

22°) Method of phytoremediation according to claim 21, characterized in that it involves the extraction of at least one of the following heavy metals: Zn, Co, Cd or Pb, from soil.

23°) Method of phytoremediation according to claim 21 or claim 22, characterized in that the entire plant is removed after it has been allowed to grow on metal-containing soil.

24°) Method of phytoremediation according to claim 21 or claim 22, characterized in that at appropriate time intervals, metal containing tissues are removed from the plant, said plant being left alive.

25°) The method of claim 24, wherein leaves and possibly branches are removed.

26°) Method of phytoremediation according to claim 24 or claim 25, characterized in that the collected plant tissues are removed from the growing area and

properly disposed, so that the metal containing tissues are not allowed to reassimilate in the soil.

27°) Method of phytoremediation according to claim 24 or claim 25, characterized in that said heavy metals may be extracted, in the M^{n+} state, from said
5 plant tissues.

28°) Method of phytoremediation according to claim 24 or claim 25, characterized in that said heavy metals are extracted from ashes obtained after having burnt the collected metal containing tissues, said metal being in the M^0 state.